

# Extraction Of $\Delta g/g$ From Hermes Data On Inclusive Charged Hadrons

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**Abstract.** Hermes has measured longitudinal double spin asymmetries as a function of transverse momentum  $p_T$  using charged inclusive hadrons from electroproduction off a deuterium target. At  $p_T > 1$  GeV, the asymmetries are sensitive to the spin dependent gluon distribution  $\Delta g$ . To extract the gluon polarization  $\Delta g/g$ , information on the background asymmetry and the subprocess kinematics has been obtained from a Leading Order Monte Carlo model. Values for  $\Delta g/g$  have been calculated both as a function of the measured  $p_T$  and  $x$ , using two different methods, in the region  $p_T > 1.05$  GeV.

**Keywords:** hadron spin; gluons; hadron electroproduction

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## INTRODUCTION

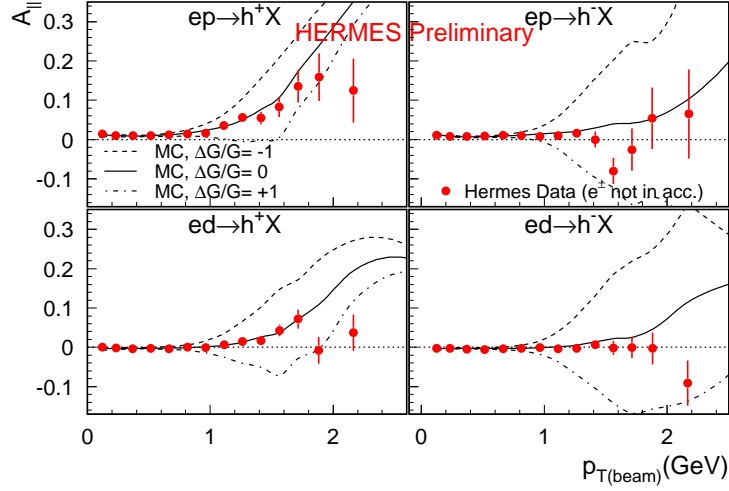
A direct, model dependent extraction of  $\Delta g/g$  has been performed by Hermes [1], SMC [2] and Compass [3, 4] for different channels and data sets. This report presents a refined extraction method, using the high statistics data sample of antitagged (vetoed by electrons or positrons), inclusive charged hadrons. A detailed study was performed to estimate the systematic error arising within the model which uses Pythia 6.2 [5], and parametrizations of spin dependent parton distributions of the nucleon and of the photon.

## EXPERIMENTAL DATA

The data sample used for this analysis was collected using the Hermes spectrometer. Charged inclusive hadrons were selected from events where neither a positron nor an electron were detected. The asymmetries were calculated as

$$A_{\parallel}(p_T) = \frac{N^- L^+ - N^+ L^-}{N^- P^+ + N^+ P^-}, \quad (1)$$

where  $N^{+(-)}$  are the number of hadrons detected with beam and target spins parallel (antiparallel),  $L^{+(-)}$  are the corresponding integrated luminosities and  $P^{+(-)}$  the integrated luminosities weighted with the product of beam and target polarizations. The transverse momentum was calculated with respect to the beam axis. The results for positive and negative hadrons from proton and deuteron targets are shown in figure 1. The asymmetries have not been corrected for acceptance and trigger efficiency. It was confirmed that the trigger efficiency does neither introduce a significant bias to the asymmetries nor to the final results. Also shown in the figure are the asymmetries expected from the model,



**FIGURE 1.** Measured asymmetries for antitagged inclusive charged hadrons. The top row shows the asymmetries for proton-, the bottom row for deuteron target. The curves show the asymmetries calculated using Monte Carlo and spin dependent quark distributions and the assumptions  $\Delta g/g(x) = -1, 0$  and  $+1$  (from top to bottom).

using the assumptions  $\Delta g/g(x) = -1, 0$  and  $+1$  (lines from top to bottom) over the full covered  $x$ -range. More detailed information on how the model asymmetries were calculated will be given below. The differences between the measured asymmetries are due to the quarks, and are well described by the curves at low  $p_T$ , where the contribution from gluons is negligible.

## INTERPRETATION IN TERMS OF THE GLUON POLARIZATION

The measured asymmetries arise from a superposition of different subprocesses contributing to the production of hadrons at a given measured  $p_T$ . In order to decompose the asymmetries and extract the signal from processes initiated by a hard gluon, the asymmetries and relative contributions of the background processes have to be known as well as the hard subprocess kinematics of the signal processes. This information was obtained from a simulation of the data using the Pythia 6.2 Monte Carlo program and a model of the Hermes detector.

### Data – Monte Carlo Comparison

The Vector Meson Dominance (VMD) Model in Pythia was adapted to reproduce the observed exclusive  $\rho^0$  cross section [6]. The fragmentation process simulated in Jetset was tuned to multiplicities of identified hadrons at  $Q^2 > 1 \text{ GeV}^2$  measured at Hermes [7]. For  $Q^2 > 0.1 \text{ GeV}^2$ , the observed semiinclusive cross sections agree typically within 15% in variables *integrated* over  $p_T$ . In contrast to this generally good agreement, the observed cross sections do not agree vs.  $p_T$ . For  $p_T > 0.7 \text{ GeV}$ , the Monte Carlo

underestimates the data by factors 2 to 4. The disagreement is most likely due to large NLO corrections as calculated in Ref. [8]. The LO result for  $\Delta g/g$  might therefore also be subject to large NLO corrections.

## Subprocess Fractions

The soft background processes from exclusive and diffractive VMD as well as non-diffractive VMD (“low- $p_T$ ”) are suppressed at high  $p_T$ , although the “low- $p_T$ ” process still contributes significantly for  $p_T < 1.5$  GeV. The quark initiated hard QCD processes together contribute less than 20% at  $p_T > 1$  GeV. At  $p_T > 1.5$  GeV, the LO DIS process dominates the cross section. Hadrons from this process originate predominantly from events with a large lepton scattering angle, where the transverse momentum calculated with respect to the beam axis overestimates the transverse momentum in the center of mass frame. The signal processes are Photon-Gluon-Fusion (PGF) and the gluon initiated  $2 \rightarrow 2$  (resolved photon) processes, each contributing 10-20% in the relevant  $p_T$  range.

## EXTRACTION METHODS AND RESULTS

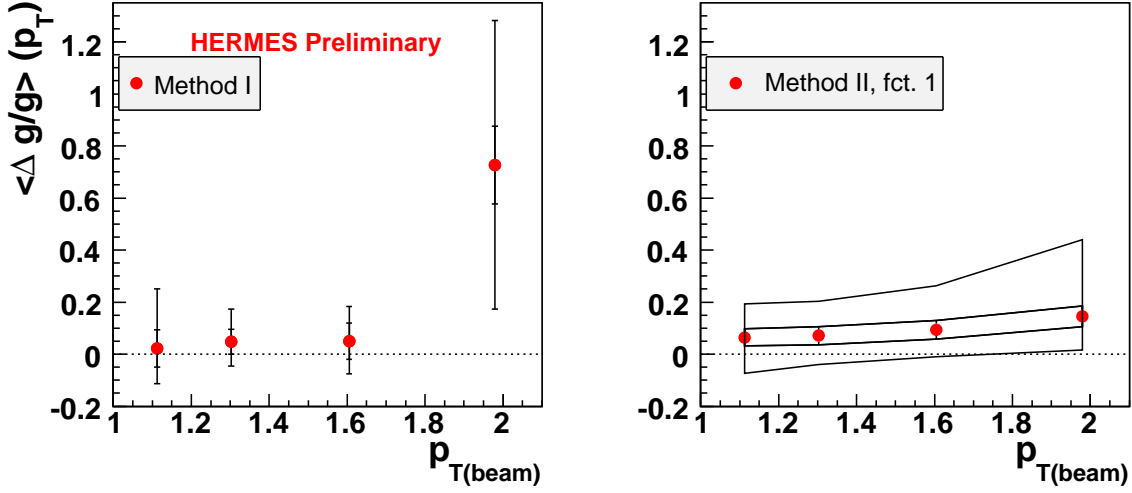
The background asymmetries for hard subprocesses were estimated using the MC information on the particle types and subprocess kinematics with the nucleon PDFs from [9] and the photon PDFs from [10], where the average of the maximal and minimal scenarios was taken. The asymmetry for exclusive VMD was set to 0, that of the “low- $p_T$ ” process was set to  $A^{\text{low-}p_T} = g_1/F_1$ , using an extrapolation of a fit to world data to lower  $x \approx 10^{-4}$ . By subtracting the background asymmetry weighted with the background fraction from the measured asymmetry,  $A_{\parallel}^{\text{meas}} - R_{BG}A^{BG} = R_{sig}A^{sig}$  the signal asymmetry can be obtained. The signal asymmetry contains a convolution of  $\Delta g(x)/g(x)$  with the (polarized) hard subprocess cross section over the  $x$ -range covered by the data. Two methods have been applied to extract the average  $\langle \Delta g/g \rangle(p_T)$  from this asymmetry using different assumptions on the shape of  $\Delta g(x)/g(x)$ . Method I assumes that  $\Delta g(x)/g(x)$  is essentially constant in the relevant  $x$ -range. Then,  $\langle \Delta g/g \rangle(p_T)$  can be found by solving the equation

$$A_{\parallel}^{\text{meas}} - R_{BG}A^{BG} = R_{sig} \left\langle \hat{a} \frac{\Delta f^{\gamma}}{f^{\gamma}} \right\rangle \left\langle \frac{\Delta g}{g} \right\rangle \quad (2)$$

for each bin in  $p_T$ . Here,  $\hat{a}$  is the hard subprocess asymmetry, and  $\Delta f^{\gamma}/f^{\gamma}$  is the polarization of partons in the resolved photon.

In Method II, a functional form is assumed for  $\Delta g(x)/g(x)$  which is used to calculate the integral  $A^{sig}$  for each  $p_T$  bin. The functional parameter(s) are determined by minimizing  $\chi^2$  for the difference  $A_{\parallel}^{\text{meas}} - R_{BG}A^{BG} - R_{sig}A^{sig}$  using all bins in  $p_T$ .

Values for  $\langle \Delta g/g \rangle(p_T)$  have been obtained from the deuterium data on charge combined hadrons, for 4 bins in  $p_T$  between 1.05 and 2.5 GeV. The results are shown in figure 2 for both Methods. Note that, in Method II, the results and errors are correlated through the fit function. Method I was used to confirm the overall consistency



**FIGURE 2.** Results for  $\langle \Delta g/g \rangle(p_T)$  from Method I (left) and Method II (right) for the antitagged deuteron data. The inner error bars (band) correspond to the statistical errors, the outer error bars (band) to the total errors.

between different independent data sets from proton and deuteron targets and positive and negative hadrons. The experimental systematic error is approximately 14% and arises from the uncertainties in the beam and target polarization measurements. It is small compared to the model uncertainty which was estimated by varying the Pythia model parameters, the unpolarized PDFs in the MC generation, the polarized PDFs in the asymmetry calculation and the assumption used for the asymmetry of the “low- $p_T$ ” process. For Method II, the functional form was also varied. No error was assigned on the Pythia model itself, and, because this is a leading order approach, also no error was assigned to account for NLO corrections. Method II allows to determine the average  $x$  of the measurement, and by integrating over  $1.05 < p_T < 2.5$  GeV a value of  $\Delta g/g = 0.071 \pm 0.034(\text{stat}) \pm 0.010(\text{sys} - \text{exp})^{+0.127}_{-0.105}(\text{sys} - \text{Models})$  has been obtained at  $\langle x \rangle = 0.22$  and  $\langle \mu^2 \rangle = 1.35$  GeV<sup>2</sup>.

## REFERENCES

1. A. Airapetian, et al., *Phys. Rev. Lett.* **84**, 2584 (2000), hep-ex/9907020.
2. B. Adeva, et al., *Phys. Rev. D* **70**, 012002 (2004), hep-ex/0402010.
3. E. S. Ageev, et al., *Phys. Lett. B* **633**, 25 (2006), hep-ex/0511028.
4. K. Kurek, “ $\Delta G/G$  from COMPASS,” in *Proc. of the 14th International Workshop on Deep Inelastic Scattering and QCD (DIS2006)*, April 20–April 14, 2006, Tsukuba, Japan, 2006.
5. T. Sjöstrand, et al., *Comput. Phys. Commun.* **135**, 238 (2001).
6. P. Liebing, *Can the Gluon Polarization in the Nucleon Be Extracted from HERMES Data on Single High- $p_T$  Hadrons*, Ph.D. thesis, Universität Hamburg (2004), DESY-THESIS-2004-036.
7. A. Hillenbrand, *Measurement and simulation of the fragmentation process at HERMES*, Ph.D. thesis, Friedrich–Alexander–Universität Erlangen–Nürnberg (2005), DESY-THESIS-2005-036.
8. B. Jäger, M. Stratmann, and W. Vogelsang, *Eur. Phys. J. C* **44**, 533 (2005), hep-ph/0505157.
9. M. Glück, E. Reya, M. Stratmann, and W. Vogelsang, *Phys. Rev. D* **63**, 094005 (2001).
10. M. Glück, E. Reya, and C. Sieg, *Eur. Phys. J C* **20**, 271 (2001).